

Contractor Report
Permanent Markers Monument Survey

Waste Isolation Pilot Plant
Carlsbad, New Mexico

August 31, 2000

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1.0 Introduction

The Waste Isolation Pilot Plant (WIPP) has been constructed by the U.S. Department of Energy (DOE) in southeastern New Mexico as a disposal facility for transuranic (TRU) wastes. The WIPP is subject to the provisions of U.S. Environmental Protection Agency (EPA) environmental protection standards defined in 40 CFR Part 191 (EPA, 1993) and compliance certification criteria set forth in 40 CFR Part 194 (EPA, 1998).

These standards and compliance criteria include requirements pertaining to the implementation of a system of passive institutional controls (PICs) for the WIPP. PICs are required by 40 CFR 191.14(c) and 40 CFR 194.43. The primary purpose of the PICs program is to provide a permanent record that identifies the location of the repository and its dangers, thus reducing the likelihood of inadvertent human intrusion into the repository. The EPA regulations specify that radioactive waste disposal systems must be designated by multiple PICs including permanent markers and long-term records.

The DOE Carlsbad Area Office (CAO) is currently implementing programs to ensure full compliance with the provisions of these standards and compliance criteria. As part of this implementation activity, alternative materials for the construction of permanent markers are being investigated. One of the considerations important to the selection of markers materials is the ability of the marker material to be inscribed with warning messages and the durability of these messages over very long time frames.

In its Compliance Certification Application (CCA) for the WIPP (DOE, 1996), the DOE provides details regarding the implementation of the permanent markers program. An important objective of the program is to develop information useful in optimizing the design of the marker systems by evaluating alternative configurations, alternative materials and aid in the development of final designs. One related activity identified in the CCA is the survey of monuments within 150 miles of the WIPP site, to obtain any information useful in the selection of markers materials and the development of markers designs.¹

This report documents the results of a survey performed by John Hart and Associates, P.A. of Albuquerque, New Mexico, working under contract to the Westinghouse Government Environmental Services Company, LLC in the summer of 2000. The objective of this survey was to collect and compile information relevant to the assessment of the durability of ancient inscriptions made on various rock types.

¹Several of the sites surveyed for this report are outside the 150-mile zone surrounding the WIPP. These sites were included in the survey as the number of available sites within the 150-mile zone is limited. These sites provide relevant information within similar climatological zones.

1.1 Related DOE Commitments

The WIPP Compliance Certification Application (CCA) includes a DOE commitment to perform a survey of monuments within a given area surrounding the WIPP site. The DOE commitment is in regard to testing to take place during the disposal phase; it is quoted below.

The major subjects which may be evaluated during this testing program are:

- *Survey representative monuments within a 150 mile radius of the WIPP to more extensively evaluate the climatic environmental affects on granite.*

In regard to the timing of this activity, the DOE states:

The following activities described in Appendix PIC will be addressed in the first five years of WIPP operation:

Survey stone monuments within a 150 mile radius of WIPP to evaluate the environmental affects on various types of granite (blue, gray, black etc.).

1.2 Study Objectives

The objective of the survey was to determine how well various rock types, within similar climatological zones, have performed as media for inscriptions in terms of both legibility and durability. The assumption inherent in this objective is that old inscriptions in rock are analogs for the WIPP permanent markers; therefore, the older the inscription, the greater the relevance. The study objective includes increasing the understanding of the effects of several independent factors that affect rock inscriptions – rock texture and hardness, intrinsic rock durability, location and orientation (aspect) of inscriptions, and climate and weathering processes. Specific objectives that derive from these general objectives include documenting:

- C rock properties
- C inscription characteristics
- C apparent age of inscriptions
- C exposures to and processes of weathering and erosion

2.0 Survey Rationale and Methods

The rationale for the performance of the survey and the methods employed are described in this section. The rationale discussion addresses the selection of monument types, site selection criteria, and background studies. The methods discussion addresses site access factors and a description of measurements taken and observations made in the field.

2.1 Selection of Monument Types

The CCA commitment, discussed in Section 1.1 above, to perform a monument survey contains little guidance regarding the definition of “monument” and what types of monument should be surveyed. The term “monument” is commonly used to mean a grave marker or historical marker. Restricting the term to those meanings would limit the types of monuments to those erected during the historic period, say the last four hundred years. To determine whether any inscriptions are analogous in durability to that sought for the WIPP permanent markers, the definition of “monument” for this study was interpreted to include any material bearing an inscription, regardless of message or intent, that has remained in place and exposed to the elements for longer than the historic period. Using this definition, the monuments that were left were those most analogous to the WIPP permanent markers – petroglyphs of prehistoric age and fully exposed to environmental stresses.

2.2 Survey Site Selection Criteria

Sites included in the survey were selected on the basis of their individual relevance to the WIPP permanent marker performance requirements (set forth in the Draft *Permanent Markers Implementation Plan* (DOE, 1999)), similarities in material types to rock materials considered for use at the WIPP site, similar climatological setting, maximum age, and the least amount of preservation or restoration. Specifically:

1. Sites were limited to those that contain rock types that might be used in the permanent markers. Included were sites with durable sandstone, fine-grain igneous rocks (basalt, rhyolite, andesite) and coarse-grain igneous rock (e.g.; granite, diorite).
2. Sites were limited to those that are located in arid to semi-arid climates at elevations up to those that sustain pinon-juniper woodlands, but not higher elevations that receive more rainfall and support larger trees.
3. Sites were selected from those known or suspected to contain inscriptions that are at least 600 years old, with preference given to the oldest sites.

4. Sites were eliminated from consideration if they had received major restoration or artificial preservation (measures other than protection from vandalism or collection).
5. Sites were limited to those that contain rock inscriptions (petroglyphs); rock paintings (pictographs) were considered to be irrelevant to the WIPP permanent marker design because all messages on WIPP markers are planned to be inscribed.

2.3 Background Studies

Given the survey site selection criteria, background studies were focused on publicly available information sources, principally archeological reports and publications that deal with pre-Columbian cultures and rock art. Contacts were made with state and federal parks, the U.S. Bureau of Land Management, the U.S. Forest Service, the Western Archeological and Conservation Center in Tucson, Arizona, and the Rock Art Museum in Tempe, Arizona. The Museum of New Mexico Laboratory of Anthropology provided the majority of background information used in this survey; direct personal assistance was received from Curtis Schaafsma, Curator of Anthropology, and Polly Schaafsma, both of whom shared their own extensive experience with southwest rock art as well as the Laboratory's field records of their own surveys of many of these sites.

2.4 Site Access

The initial list of sites that met the selection criteria included 17 sites (including two sites at Rowe Mesa) in New Mexico and two in Texas (Figure 1). Of the 16 sites surveyed, five are on private or leased land, five are on public land, and six are on state or federal parks or monuments. Owners or lessees of lands with petroglyphs were contacted for permission to enter and conduct survey activities. Public agencies including the New Mexico State Land Office, the U.S. Bureau of Land Management, and the U.S. Forest Service were contacted for public land access and required fees were paid. Entry fees were paid where required for entry to parks and monuments.

Three sites were eliminated from the survey. One of these (Diablo Canyon) is on public land in Texas but could not be accessed because all roads to the site cross private land and all had gates that were locked due to recent vandalism. One New Mexico private landowner refused permission to the Olive Buttes site for access for reasons not given. The third site, Luna #5, could not be found in the field.

2.5 Measurements and Documentation

Measurements and observations were made at each site to satisfy the specific objectives of the study as outlined above. A more detailed description of those objectives is provided below:

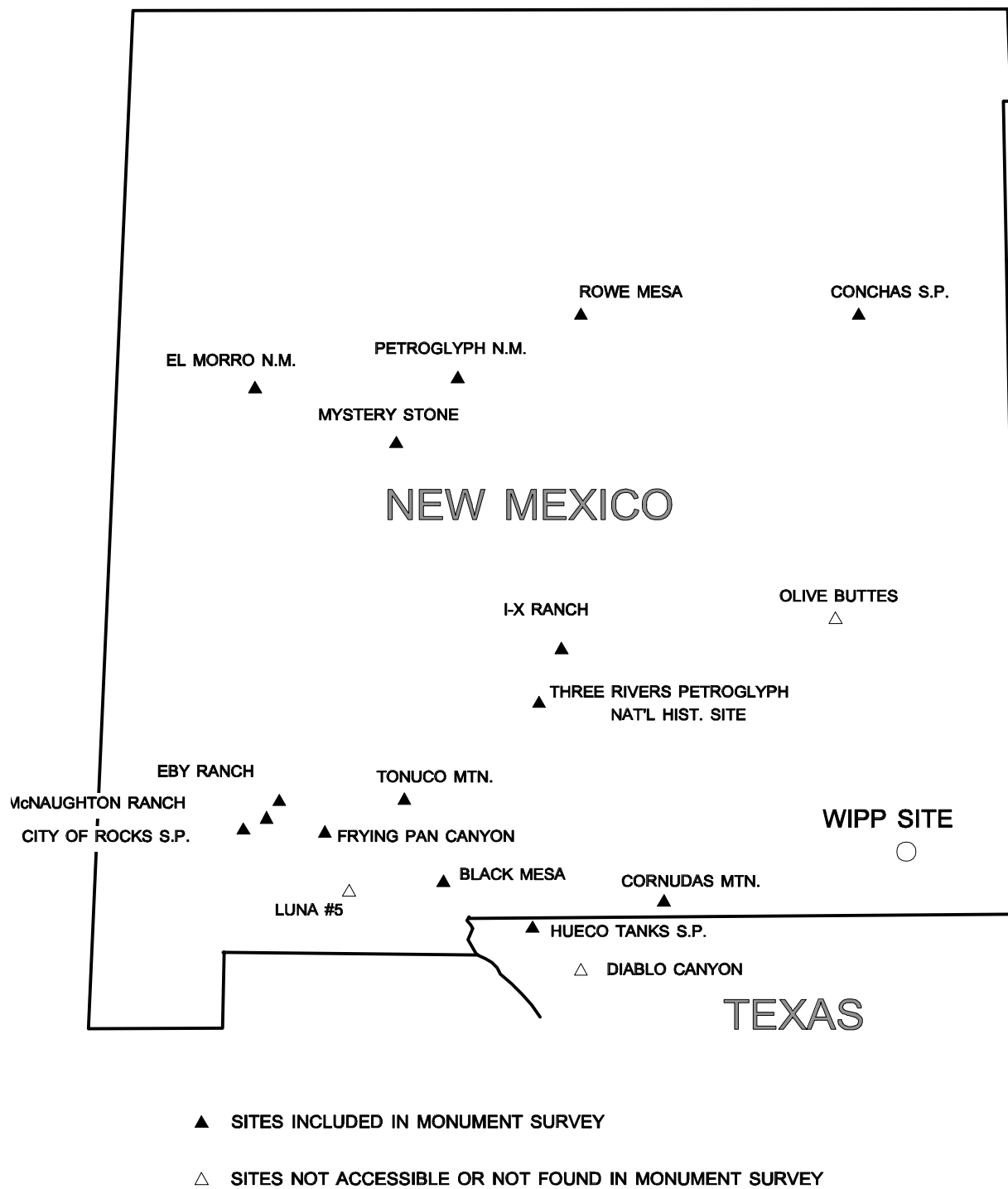


Figure 1. Monument survey sites

Rock properties important to the durability and inscribability of the rock included petrologic classification, texture, surface form and roughness, type and extent of weathering, and overall extent of patination (see Section 3.5 for a discussion of patination).

Inscription characteristics included apparent inscription type (i.e.; chiseled, scraped, pecked), form, range of widths and depths, and aspect (direction and inclination of inscribed surface).

Apparent ages of inscriptions were estimated based on the types of images, relative position of multiple layers of images, evidence of weathering within the inscription, amount of repatination and lichen growth on the inscriptions.

Exposures to and processes of weathering and erosion were evaluated from the position of the petroglyphs with respect to slopes, watercourses, surrounding terrain features and the climatic zone.

Observations and measurements were recorded on site data worksheets. Digital photographs were made to illustrate representative characteristics of rocks and their petroglyphs.

3.0 Survey Findings

Data collected during the survey are described in this section. The descriptions include rock types encountered, types of inscriptions, exposure of inscriptions, inscription condition, and inscription ages. Photographs of inscriptions (petroglyphs) referred to throughout this report are included as Attachment 1.

3.1 Site Reports

Site reports were prepared for each site visited during the survey and are included as Attachment 2 of this report. Some salient features of the sites are summarized in Table 1.

3.2 Rock Types

Petroglyphs surveyed in this study were inscribed into sandstones (six sites), fine-grained igneous and pyroclastic rocks (eight sites), and coarse-grained igneous rocks (two sites). The sandstones were all well indurated and resistant to erosion as evidenced by their positions as cliff formers or caprock on mountains. Petroglyphs were inscribed more deeply in sandstone than in the other rock types, but all rock types found in the survey preserved the inscriptions well. The only difference in durability was related to exfoliation, as discussed below.

3.3 Methods and Forms of Inscription

At all surveyed sites, pre-Columbian inscriptions had been made by pecking or scraping. Although both forms of inscription have survived for hundreds to thousands of years, the pecked images are deeper and, therefore, appear to be more durable.

Pecked inscriptions are characterized by contiguous crater-shaped pits in the rock surface, each about 1-3mm wide and deep, apparently made by a pointed stone or antler struck by another stone to break out small pieces from the rock surface (Photo #1). Pecked images usually have sharply defined lateral boundaries and are 2mm or more in depth.

Scraped inscriptions were apparently made by simply scratching the rock surface with a stone (Photo #2). Lateral boundaries of the scraped images were less well defined, especially on rough coarse-grained surfaces. Scraped inscriptions were less than 2mm deep, often too shallow to measure.

Widths of both pecked and scraped inscriptions vary widely, depending on the image. However, none of the surveyed images were less than 3mm wide, and most were at least 5mm wide.

Table 1. Features of Petroglyphs at Surveyed Sites

Site Name And Location	Rock Type	Inscription Age(s)	Method of Inscription	Level of Exposure	Condition of Inscriptions
Mystery Stone Valencia Co., NM	Andesite	Anasazi to recent	Pecked, Chiseled	High	Fair
I-X Ranch Lincoln Co., NM	Andesite Porphyritic	Archaic, Mogollon	Pecked, Scraped	High to Extreme	Fair to Good
Three Rivers National Rec. Site	Andesite Porphyritic	Mogollon	Pecked, Scraped	Extreme	Fair to Good
Black Mesa, Doña Ana Co., NM	Basalt	Archaic, Mogollon	Scraped, Pecked	Moderate	Fair
Petroglyph N.M., Albuquerque, NM	Basalt	Archaic, Anasazi	Scraped, Pecked	Moderate	Fair
Hueco Tanks S.P. Hudspeth Co., TX	Diorite	Mogollon	Pecked	Sheltered to Slight	Fair to Good
Cornudas Mtn., Otero Co., NM	Diorite Porphyritic	Archaic, Mogollon	Scraped	Moderate	Good
Eby Ranch, Faywood, NM	Rhyolitic Welded Tuff	Archaic, Mogollon, Apache, recent	Pecked	High	Good to Poor
McNaughton Ranch, Luna Co., NM	Rhyolitic Welded Tuff	Archaic, Mogollon	Scraped	High	Good to Poor
City of Rocks S.P. Faywood, NM	Rhyolitic Welded Tuff	Mogollon (Mimbres)	Scraped	Sheltered	Good
Frying Pan Canyon Luna Co., NM	Sandstone	Archaic, Mogollon	Pecked, some Scraped	High to Extreme	Good
Tonuco Mtn., Doña Ana Co., NM	Sandstone	Archaic, Mogollon	Pecked	Moderate to High	Fair to Good
El Morro N.M. Cibola Co., NM	Sandstone	Anasazi to recent	Pecked, Chiseled	Moderate	Fair to Poor
Conchas Lake S.P., San Miguel Co., NM	Sandstone	Archaic, Anasazi	Pecked	Moderate	Good
Rowe Mesa Site #1, San Miguel Co.,NM	Sandstone	Archaic	Pecked	Extreme	Fair
Rowe Mesa Site #2, San Miguel Co., NM	Sandstone	Archaic	Pecked	Extreme	Fair

At one site, the “Mystery Stone” in Valencia County, New Mexico, the rock is inscribed with V-shaped grooves about 2mm deep and 3-5 mm wide (Photo #3). The grooves are very uniform, straight, and consistent throughout the very large inscription. Fresh rock powder is still stuck to the bottoms of some of the grooves. It is evident that this inscription was made with a hard metallic tool.

3.4 Aspect and Level of Exposure

As used in this survey, aspect means the direction and inclination of the petroglyph surface. Directions and inclinations were measured by field compass and recorded according to approximate direction (e.g.; NE, W, SW) and to the nearest 10 degrees inclination from horizontal. Petroglyph aspects covered the whole range of possible direction as well as inclinations from horizontal to 20 degrees past vertical. No discernible difference in petroglyph condition was observed, based on aspect.

Level of exposure is a qualitative description of the location of the petroglyphs with respect to sun, rain, wind and runoff. Extreme exposure is a condition without shelter, totally exposed to sun during all seasons and daylight hours, to wind and rain from all directions, and to local runoff. High exposure indicates shelter from wind and runoff from one half of the compass rose, but otherwise fully exposed. Moderate exposure means exposure to half the compass rose and some shelter from adjacent terrain. Slight exposures have limited direct sun and protection from all but one quadrant of wind and rain. Sheltered locations are surrounded by obstacles to wind and sun or located on the underside of inclined rocks. The differences in exposure of petroglyphs at any site did not result in measurable differences in the condition of those petroglyphs, nor were discernible differences observed between sites based on exposure.

3.5 Inscription Condition and Visibility

Several factors that affect inscription condition and visibility were observed and evaluated: inscription size, contrasts in texture and color, boundary sharpness, and mechanical weathering.

The importance of *inscription size* is obvious; larger petroglyphs were easier to see. Inscription depths and widths affect visibility and, as stated above, were measured. Deeper inscriptions were more visible than shallow inscriptions on repatinated surfaces at close range, but wider inscriptions, regardless of depth or repatination, were more visible at a distance.

Visibility of petroglyphs was strongly affected by *contrasts in texture and color* between the host rock and the inscription grooves, and this contrast was more important than size, width, or depth in being able to locate petroglyphs. The color and texture of rock surfaces in the Southwest that have been exposed for long periods of time are commonly darkened and muted by a patina that results from a combination of chemical and microbial processes not yet well understood. In nearly all the sites surveyed, the petroglyphs were created by breaking the patinated layer, usually the outermost 1-2 mm of darkest color, leaving a groove that is a lighter color or different texture than the undisturbed surface (Photos #4 and 5). Over time, from several hundreds to thousands of years, the inscription is repatinated; i.e., the patina reforms on the disturbed rock surface. Even if a petroglyph is relatively large, it might be easily missed if it is totally repatinated, while a very small petroglyph with sharply contrasting color or texture (no repatination) would be very visible (Photo # 6).

Boundary sharpness is the visible distinction between the inscription groove and the adjacent rock surface. Observations of the oldest petroglyphs, those of Archaic age, reveal that boundary sharpness deteriorates over time. Edges of grooves gradually round to a flattening transition to the uninscribed rock; in effect, the inscription broadens and its slopes flatten (Photo #7). If this loss of groove boundary sharpness is accompanied by repatination, the visibility of the inscription is greatly reduced (Photo #8).

Mechanical weathering contributes gradually and on a small scale to loss of boundary sharpness, but it also acts on a larger scale in the form of scaling or exfoliation. The exfoliation process was most obvious in the intrusive igneous rocks of the Cornudas Mountain site (porphyritic diorite) and Hueco Tanks site (diorite), as shown in photos #9, 10, and 11. In exfoliation, the rock surface gradually peels away like an onion skin in thin (5-20mm) layers. Similar scaling of rock surface, although less regular, was observed in sandstone (Photo #12) and andesite (Photo #13).

Inscription condition was assessed primarily on the basis of visibility but also included consideration of the groove depth and boundary sharpness. Excellent condition was reserved for petroglyphs that looked fresh and sharp, a description applicable only to historic inscriptions at El Morro, that are discounted for this study. Good condition indicates clear visibility, measurable depth, and no apparent erosion of the inscribed surface (Photo #14). Fair condition means some degradation in visibility or depth, in some cases with erosion (exfoliation or spalling) in some locations (Photo # 15, 16). Poor condition describes inscriptions that are difficult to see due to erosion, weathering, or perhaps less than typical original craftsmanship. Two sites with exposed petroglyphs on rhyolitic welded tuff had a number that were in poor condition (Photos # 17 and 18). At all other sites, petroglyphs were mostly in fair to good condition.

3.6 Petroglyph Ages

In general, absolute ages of petroglyphs are impossible to determine directly. For this survey, previous studies by Polly Schaafsma and others were used to identify the cultural periods and approximate ages of petroglyphs in the area of interest and to select the sites with the oldest (Archaic) petroglyphs (Schaafsma, 1972; Schaafsma, 1979). Curtis Schaafsma and Polly Schaafsma indicated that petroglyph ages are estimated based on correlation of images depicted in petroglyphs with identical or similar images in pottery and other artifacts on which dating techniques, such as carbon-14 isotope concentrations, have produced absolute ages (personal communication, May 18, 2000).

The age of petroglyphs examined in this survey range from less than 100 years to as much as 6000 years. Emphasis was placed on Archaic age petroglyphs, ranging in age from about 1800 years to 6000 years, which were examined at 10 of the 16 sites surveyed. Petroglyphs of Mogollon and Anasazi age, about 600 to 1800 years old, were examined at 13 sites, including seven that also contain Archaic petroglyphs. The Archaic petroglyphs are called Desert Abstractions and are characterized by geometric patterns that do not represent any life form or cultural object

(Schaffsma, 1979). These patterns include parallel straight or wavy lines, circles in concentric or chain patterns, cross-hatched or intersecting diagonal lines, circles with radial lines, and irregular lines (Photos #19 and 20). Mogollon and Anasazi petroglyphs also include circles but are more representational, depicting human forms (anthropomorphs), animals, spirits, and weapons (Photos #21 and 22). Apache and other more recent cultures have left inscriptions at some of the sites, but they can usually be distinguished by the absence of repatination or lichens. At several sites, a type of lichen with bright chartreuse color has formed in the inscription grooves (Photos #23, 24, and 25), fixing the minimum age of the petroglyph at about 600 years, the time this lichen takes to get established on a rock surface (C. Schaafsma, personal communication, May 18, 2000).

The actual ages of petroglyphs at two sites, Rowe Mesa Site #1 and #2, have been established by two independent scientific methods, carbon-14 dating and soil morphology. At these sites, the petroglyphs are on a flat sandstone surface. Over at least part of those surfaces a soil profile was developed, then partially eroded. A charcoal layer at the rock-soil contact and the soil profile morphology have independently provided ages for the underlying petroglyphs of about 5900 years (Brent Abel, USFS, personal communication, June 16, 2000)(Photos # 26 and 27).

4.0 Conclusions

Reasonable conclusions based on the results of the monument survey are identified in this section. Issues such as the durability of various rock types, the effects of aspect, the rates of erosion of inscriptions, the effects of inscription form, and the importance of contrast in color and texture are addressed.

4.1 Durability of Rock Types

The petroglyphs examined in this survey involved the most common types of hard rock occurring in the Southwest with the exception of granite, on which no petroglyphs of prehistoric age have been identified within a few hundred miles of the WIPP site. All the petroglyph rocks are very durable and resistant to erosion, but not all are apparently capable of preserving inscriptions for thousands of years. The intrusive igneous rocks most like granite, the porphyritic diorite of Cornudas Mountain and the diorite of Hueco Tanks, exhibited exfoliation that caused gradual loss of petroglyph inscriptions. Because exfoliation is a common weathering mechanism of intrusive igneous rocks, this class of rocks would probably not be able to keep an inscribed surface intact for more than a few thousand years. If not jointed or otherwise fractured, the other rock types (sandstone, basalt, andesite, and rhyolite/welded rhyolitic tuff) appears to weather more evenly and to be able to retain inscriptions for thousands of years. Chemical weathering rates are relatively slow in the arid Southwest climate, so all of these rock types should be able to remain chemically intact for at least 10,000 years and possibly much longer. Therefore, any of these rocks could be considered for use in the WIPP permanent markers.

4.2 Effects of Aspect

The direction and inclination of the petroglyph surface has no observed effect on the longevity of the petroglyph. This conclusion seems to be contrary to logic; surfaces exposed to the prevailing wind direction should show more erosion. Nevertheless, survey observations revealed no aspect that was better for petroglyph survival than any other.

4.3 Rates of Erosion of Inscriptions

None of the survey observations were able to support a determination, or even a reasonable estimation, of erosion rates of inscriptions. Although measurements of inscription depth might have revealed differences in erosion rates according to aspect or rock type, in fact differences in inscription depth could not be attributed directly to erosion because 1) the inscription depths at each site do not vary measurably from one petroglyph to the other, and 2) the original depths of inscriptions cannot be ascertained. It is worth noting, however, that where the soil covered only

about half of a petroglyph at the Rowe Mesa #1 site, the inscription depths of the covered side are not measurably different from the uncovered side.

Lacking any data to indicate to the contrary, it is reasonable to conclude that petroglyphs will erode at the same rate as the rest of the rock surface. Considering the fact that the petroglyph rock surfaces are generally patinated and the older petroglyph grooves are repatinated, it is apparent that the rate of inscription erosion must be less than the rate of patination, which takes hundreds to thousands of years to develop to a depth of 1-2mm. This conclusion is consistent with the fact that even scraped Archaic inscriptions less than 1mm deep have survived at least 1800 years.

The apparent substantial durability of the several rock types bearing petroglyphs indicates that erosion rates of rock surfaces are slow enough to lend confidence that rock inscriptions can last at least 10,000 years. It also supports the conclusion that chemical weathering and mechanical weathering rates are very slow in the Southwest.

4.4 Effects of Inscription Form

The form of the inscriptions (shape, depth, and width) is remarkably consistent between generations of petroglyphs at each site and between sites for each archeological period. Petroglyphs that have familiar shapes, like circles and human bodies, are more readily recognized than irregular shapes, regardless of age. Circles exist at all the petroglyph sites, and during the field surveys a circle was frequently the first image noticed and the visual trigger to look more closely for other petroglyphs. Shapes that are similar to natural rock contours, like curves and wavy lines, are more difficult to see, especially in mid-day light.

Depth of inscription, while possibly having an impact on inscription durability, has little effect on image visibility, but groove width is very important, especially on rock surfaces with more coarse textures due to either mineral particle size or surface roughness. On coarse-texture surfaces, grooves narrower than the amplitude of roughness or the largest mineral size are difficult to see, especially under low sun angles.

4.5 Importance of Contrast in Color and Texture

The contrast between color and texture of the inscription groove and the color and texture of the host rock surface is the most important factor in the visibility and legibility of petroglyphs that are inscribed into patinated rock surfaces. As important as this color contrast is in recognizing petroglyphs, its importance will be much less for any WIPP permanent marker inscriptions, which would be placed on fresh, unpatinated rock surfaces. Patination of the marker surfaces would probably develop at the same rate across the whole marker surface, including the inscription grooves, so it is unlikely that color contrast would ever contribute to the visibility of the WIPP

inscriptions.

The primitive tools of the Archaic and Mogollon/Anasazi people were not capable of producing smooth grooves. The grooves of the recent “Mystery Stone” inscriptions are not deeper or wider than the older petroglyphs, but both the Mystery Stone grooves and historic age grooves of El Morro’s Inscription Rock are more visible because the metal tools used to create them were capable of making sharp boundaries and smooth surfaces in the grooves. The sharp edges and smooth surfaces of the grooves provide a distinct textural contrast that makes the inscription stand out visually.

5.0 Recommendations

Recommendations based on the monument survey are provided in this section. Recommendations are provided on rock type, form of inscriptions, and additional studies.

5.1 Rock Type

Rocks of hardness and durability suitable for use as WIPP permanent markers are available within a few hundred miles of the WIPP site. Basalt and sandstone are the most abundant, so one or both of these should be selected for further evaluation, including durability and inscribability testing. Granite and other intrusive igneous rocks that are susceptible to exfoliation should not be used.

5.2 Form of Inscriptions

To the extent consistent with the necessary written and symbolic warnings and messages, inscriptions should be as large as possible, with groove widths several times the largest mineral particle size. Unless the rock is very fine grained like basalt, it probably will not be practical to inscribe letters smaller than about 25mm minimum plan dimension or less than 5mm deep.

5.3 Additional Studies

Given the consistent findings over the 16 sites included in this survey, it is anticipated that additional monument (petroglyph) surveys would not be useful. However, studies on material properties of rock and man-made materials would be useful, with emphasis on surface hardness, methods to create and preserve color contrast, and the effects of rock texture on inscribability and inscription durability.

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Attachment 1

Report Photographs



Photo #1. Close-up view of petroglyph pecked through patina on basalt. Petroglyph National Monument.



Photo #2. Petroglyph scraped into patina at Frying Pan Canyon.



Photo #3. Sharp V-shaped grooves of this inscription at Mystery Stone indicate that this petroglyph was made by metallic tools and is recent.



Photo #4. Petroglyphs at Cornudas Mountain, showing effects of color and texture contrasts on visibility of images.



Photo #5 – Circle image at end of pointer is repatinated to background color and texture, while images to left are unpatinated, aiding visibility. McNaughton Ranch.



Photo #6. Very small petroglyphs that visually stand out because of contrasts in color and texture with surrounding rock. Frying Pan Canyon.



Photo #7. Petroglyph on horizontal surface at Rowe Site #2 with edges rounded and flattened by weathering and erosion.



Photo #8. Circle with cross, barely visible due to repatination and loss of boundary sharpness. Eby Ranch site.



Photo#9. Petroglyphs gradually being lost to exfoliation (lighter area). Cornudas Mountain Site



Photo #10. Archaic petroglyph above exfoliating surface. Cornudas Mountain.



Photo #11. Exfoliation in diorite, lower right corner, encroaching on Archaic “chain” and recent script images. Hueco State Park.



Photo #12. Remnant of inscribed surface in water course gradually being lost spalling and erosion. Frying Pan Canyon.



Photo #13. Petroglyph with left half lost to spalling. I-X Ranch.



Photo #14. Petroglyph in good condition in sandstone at Frying Pan Canyon.



Photo #15. Petroglyphs in lower part of panel are in fair condition. Cornudas Mountain.



Photo # 16. Petroglyph in fair condition, with some spalling and erosion. Tonuco Mountain.



Photo # 17. Petroglyph of concentric circles, in poor condition. Eby Ranch.



Photo # 18. Chain of circles (Archaic), with lowest two circles deteriorated to poor condition. McNaughton Ranch.



Photo #19. Archaic Desert Abstractions at Conchas Lake State Park.



Photo #20. Typical Archaic line patterns. McNaughton Ranch.



Photo #21. Mogollon images including animal, anthropomorphic, and other representational forms. Three Rivers Petroglyph National Historic Site.



Photo #22. Mogollon (Jornada) spirit mask. Black Mesa.



Photo #23. Chartreuse-colored lichens on Archaic petroglyph. Tonuco Mountain.



Photo #24. Chartreuse lichens highlighting Mogollon mask. Tonuco Mountain.



Photo # 25. Lichens growing in Archaic comb form. I-X Ranch.



Photo #26. Soil cover partially removed from petroglyphs on horizontal surface. Rowe Mesa Site #1.



Photo #27. Petroglyphs extending into the open from underneath soil cover. Rowe Mesa Site #2.

Attachment 2

Site Reports

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: Three Rivers Petroglyph National Historic Site
LOCATION: Otero Co., NM
SITE OWNED BY: Bureau of Land Management
ACCESS AUTHORIZED BY: Public access, fee paid
SITE VISIT DATE: 6/14/00
BY: A. Kuhn, K. Lickliter, S. Casey

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Porphyritic Andesite

AGE(S) OF PETROGLYPHS: Mogollon

INSCRIPTION TYPE OR METHOD: Pecked, some scraped

INSCRIBED SURFACE ASPECT

DIRECTIONS: All directions, mostly south and southwest

INCLINATIONS: 70 degrees to vertical

ROCK SURFACE FORM: Varies widely from flat to curved, moderately smooth-to-rough

INSCRIPTION GROOVE FORM

WIDTHS: 3-20mm

DEPTHS: <2mm, most <1mm

WEATHERING: Rock surfaces patinated, petroglyphs not repatinated.

PHOTOS:	#	Description
	ThreeR~1	Assortment of superimposed figures including Aztec-like geometrics and a rabbit.
	ThreeR~2	Images on adjacent boulders including representational fish, footprint, and circle with cross.
	ThreeR~3	Concentric circles surrounded by dots; this figure appears many places.
	ThreeR~4	Geometric patterns of multiple ages; pole pointing to oldest partly repatinated figure.

NOTES: This andesite has large (5-15mm) mafic phenocrysts that cause some of the narrower inscriptions grooves to be partially obscured. The petroglyphs were made by pecking or scraping only deep enough to break through the patina. There are at least two generations of petroglyphs here, as shown by the superposition of petroglyphs. This site has suffered some vandalism in the form of recent scratching of petroglyph images.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: Black Mesa
LOCATION: Doña Ana Co., NM
SITE OWNED BY: Stahmann Farms
ACCESS AUTHORIZED BY: Dave Lowry, Stahmann Farms
SITE VISIT DATE: 5/30/00, 6/2/00
BY: A. Kuhn, K. Lickliter

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Basalt

AGE(S) OF PETROGLYPHS: Archaic, Mogollon

INSCRIPTION TYPE OR METHOD: Scraped, some pecked

INSCRIBED SURFACE ASPECT

DIRECTIONS: Mostly north, east, and southeast
INCLINATIONS: 80 degrees to vertical

ROCK SURFACE FORM: Mostly wavy and smooth, some rough

INSCRIPTION GROOVE FORM

WIDTHS: 5-30mm
DEPTHS: <1mm

WEATHERING: All old rock surfaces heavily repatinated, no apparent chemical weathering of the basalt minerals.

PHOTOS:	#	Description
	BlackM1	Mogollon spirit figure on wavy surface.
	BlackM2	Archaic geometric barely visible on boulder face.
	BlackM3	Zigzag line partly repatinated.
	BlackM4	Barely visible images on boulders.
	BlackM5	Archaic image obscured by patina and shadow.
	BlackM6	Sunburst pattern on surface partly broken by spalling.
	BlackM7	Same as BlackM6.
	BlackM8	Totally repatinated image left of pencil point.

BlackM9	Zigzag pattern in shadow on boulder.
BlackM10	Very faint group of images to left of pointer.
BlackM11	Same as BlackM10.
BlackM12	Centipede image.
BlackM13	Same as BlackM12.
BlackM14	Orthogonal line pattern on curved rock face below shadow, heavily repatinated.
BlackM15	Orthogonal line pattern, repatinated, below and to right of pencil.
BlackM16	Rock face with partially repatinated zigzag lines and unpatinated scratches made by earthmoving equipment.

NOTES: This site is on Stahlmann Farms property at the foot of the east slope of Black Mesa. The petroglyphs are scattered among boulders at the foot of the slope, with heavy vegetation in many places obscuring the petroglyphs. The heavy patination makes most images difficult to see and even more difficult to photograph. All images are very shallow, made by scraping the surface which is patinated to a dark gray-black color. Some of the petroglyphs are pecked but have not broken through the patina completely. The unpatinated color of the rock is a medium-to-dark gray, so the patination does not produce a strong color contrast, which also makes many petroglyphs difficult to see.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: City of Rocks State Park
LOCATION: Luna Co., NM
SITE OWNED BY: State of New Mexico
ACCESS AUTHORIZED BY: Brian Pender
SITE VISIT DATE: 6/2/00
BY: A. Kuhn, K. Lickliter

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Rhyolitic Welded Tuff

AGE(S) OF PETROGLYPHS: Mogollon

INSCRIPTION TYPE OR METHOD: Scraped

INSCRIBED SURFACE ASPECT

DIRECTIONS: (see note)
INCLINATIONS: Overhang surface

ROCK SURFACE FORM: Smooth, planar

INSCRIPTION GROOVE FORM

WIDTHS: 10mm
DEPTHS: <2mm

WEATHERING: Rock surface mostly patinated, petroglyph not repatinated

PHOTOS:	#	Description
	Cityroc1	Unidentifiable image looking like an abstract hand or tree form.
	Cityroc2	Same as Cityroc1.
	Cityroc3	Same as Cityroc1&2 using flash.
	Cityrock4	Picture of rock surface showing three different levels of patination; pencil in right hand points to most recent, ruler points to intermediate age, darks areas have oldest patina.

NOTES: This site contains several pictographs but only one petroglyph, which is inscribed on an overhanging surface in a relatively sheltered location. Patterns of patination are informative; at least three ages or levels are present.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: Conchas Lake State Park
LOCATION: San Miguel CO., NM
SITE OWNED BY: State of New Mexico
ACCESS AUTHORIZED BY: Park Superintendent
SITE VISIT DATE: 6/15/00
BY: A. Kuhn, K. Lickliter

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Sandstone

AGE(S) OF PETROGLYPHS: Archaic, some Anasazi

INSCRIPTION TYPE OR METHOD: Pecked

INSCRIBED SURFACE ASPECT

DIRECTIONS: West to south, one horizontal surface

INCLINATIONS: Vertical

ROCK SURFACE FORM: Curved, moderately rough; also one planar surface; horizontal surface is wavy

INSCRIPTION GROOVE FORM

WIDTHS: Up to 30mm

DEPTHS: 1-5mm

WEATHERING: Some surfaces are patinated; others appear to be unweathered. Some petroglyphs are repatinated.

PHOTOS:	#	Description
	Conchas1	Vertical face with concentric circles, comb patterns partly repatinated.
	Conchas2	Partly repatinated dots, more recent curved line not repatinated.
	Conchas3	Repatinated geometric figure, with fresh rock break to right.
	Conchas4	Same as Conchas1.

- Conchas5 Panel of geometric images partially repatinated except for more recent wavy line at right; high water indicated by top of grayish zone at bottom of photo.
- Conchas6 Same view as Conchas5 shifted to the right.
- Conchas7 Distant view of images in Conchas5&6.
- Conchas8 Distant view of images just above high water mark.

NOTES: The south-facing petroglyph panel is fully repatinated. Patterns are all abstract geometrics except for one quadraped. Dominant patterns are concentric circles, diamonds cross patterns, wavy lines, dots, and parallel lines. Also, one animal form with pincers and one antlered head are probably Anasazi age. Some of the petroglyphs are below the high water line of the lake and are partially obscured with deposits from the lake water.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: Cornudas Mountain
LOCATION: Doña Ana Co., NM
SITE OWNED BY: Stahmann Farms
ACCESS AUTHORIZED BY: Dave Lowry, Stahmann Farms
SITE VISIT DATE: 5/30/00, 6/2/00
BY: A. Kuhn, K. Lickliter

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Basalt

AGE(S) OF PETROGLYPHS: Archaic, Mogollon

INSCRIPTION TYPE OR METHOD: Scraped, Pecked

INSCRIBED SURFACE ASPECT

DIRECTIONS: East, South and Southwest

INCLINATIONS: 60 degrees to vertical

ROCK SURFACE FORM: Smooth

INSCRIPTION GROOVE FORM

WIDTHS: 5-80mm

DEPTHS: <2mm

WEATHERING: Older rock surfaces patinated to about 2mm. Extensive exfoliation in layers 2-10mm.

PHOTOS:	#	Description
	Cornud1	East-facing panel with Archaic and Mogollon images scraped and pecked through patina.
	Cornud2	Closeup of Cornud1 location, showing Archaic geometrics surrounded by Mogollon anthropomorphs.
	Cornud3	Southwest-facing surface with images partly lost to exfoliation.
	Cornud4	East-facing panel with several generations of images.
	Cornud5	Chain pattern on surface substantially exfoliated.
	Cornud6	Archaic pattern of parallel zigzag lines on partly exfoliated surface.

Cornud7 Panel of mixed images, mostly Archaic geometrics.
Cornud8 Same as Cornud7.
Cornud9&10 Pictographs.

NOTES: This site has extensive petroglyphs of both Archaic and Jornada (Mogollon) age, mostly scraped, some pecked, through a 2mm patina layer. Extensive exfoliation affects rock surface to depths of 5-10mm. All Jornada and older petroglyphs are at least partially repatinated. This site is exposed to the south quadrants, sheltered from the north quadrants. Phenocrysts of nepheline (?) appear to control the depth of exfoliation.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: Eby Ranch
LOCATION: Faywood, NM
SITE OWNED BY: Larry Eby
ACCESS AUTHORIZED BY: Larry Eby
SITE VISIT DATE: 6/1/00
BY: A. Kuhn, K. Lickliter

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Rhyolitic Welded Tuff

AGE(S) OF PETROGLYPHS: Archaic, Mogollon, maybe some Apache, recent

INSCRIPTION TYPE OR METHOD: Pecked

INSCRIBED SURFACE ASPECT

DIRECTIONS: Northwest to southwest

INCLINATIONS: 45 degrees to vertical

ROCK SURFACE FORM: Wavy, smooth to rough

INSCRIPTION GROOVE FORM

WIDTHS: 2-80mm

DEPTHS: Most <2mm, some up to 5mm

WEATHERING: Old rock surfaces heavily patinated, some petroglyphs completely repatinated.

PHOTOS:	#	Description
	EBY1	Concentric circles completely repatinated on wavy rough surface.
	EBY2	Hand patterns, one partly repatinated, on wavy surface.
	EBY3	Spirit form on rough, partially fractured surface.
	EBY4	Recent image of house on wavy rough surface.
	EBY5	Recent house image in lower right, recent donkey in center, and repatinated circle pattern in upper left, showing contrast in appearance of very old vs. recent inscriptions.
	EBY6	Partially repatinated geometric image.

EBY7	Pencil and pole point to limits of large circle with horizontal line, partially repatinated, with lichen growth.
EBY8	Intricate diamond pattern, repatinated, with some lichen growth.
EBY9	Wider view of EBY8 image, with recent inscription to left.
EBY10	Rough patinated surface with extensive scaling of patinated surface; pinwheel and other geometric patterns.
EBY11	Anthropomorph to right of pencil, mostly repatinated.
EBY12	Repatinated circle with cross right of pencil.
EBY13	Repatinated concentric circles right of pencil and above pencil.

NOTES: This site is on private property at the crest of a low hill capped by the welded tuff. Petroglyphs face primarily toward the western quadrants and are fully exposed to sun, wind and rain from that direction. The Archaic images and some of the Mogollon images are completely repatinated; some Mogollon images are partly repatinated. Patina development is apparently more uniform here than at other sites with the same kind of rock. Recent images were apparently made by local school children within the last 50 years.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: El Morro National Monument
LOCATION: Cibola Co., NM
SITE OWNED BY: National Park Service
ACCESS AUTHORIZED BY: Public access, fee paid
SITE VISIT DATE: 6/13/00
BY: A. Kuhn, K. Lickliter, S. Casey

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Sandstone

AGE(S) OF PETROGLYPHS: Anasazi to recent

INSCRIPTION TYPE OR METHOD: Chiseled, pecked

INSCRIBED SURFACE ASPECT

DIRECTIONS: East, south, west, most north

INCLINATIONS: Vertical

ROCK SURFACE FORM: Planar, smooth-to-rough

INSCRIPTION GROOVE FORM

WIDTHS: Various, up to 50mm

DEPTHS: Generally 3-10mm, some larger

WEATHERING: Repatinated completely on oldest petroglyphs. No repatination on historic age inscriptions. Some spalling. Lichens only on oldest petroglyph surfaces.

PHOTOS:	#	Description
	ElMorro1	Patinated surface with fully-repatinated images of hands, quadrapeds, anthropomorphs.
	ElMorro2	Line of mountain goats on unpatinated surface.
	ElMorro3	Panel of unweathered surface with many quadraped forms.
	ElMorro4	Zigzag pattern in unweathered surface.
	ElMorro5	Same as ElMorro4.
	ElMorro6	Concentric circles left of stick, scraped letters to right.

NOTES: This site has many generations of inscriptions from Anasazi to recent. Anasazi images include pecked handprints, anthropomorphic zigzag patterns, and concentric circles. Some historic age letters have dark gray-to-black lichens in them. The sandstone is very fine-grained and massive, making inscribing relatively easy compared to the other sites surveyed.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: Hueco Tanks State Park
LOCATION: Hudspeth Co., TX
SITE OWNED BY: State of Texas
ACCESS AUTHORIZED BY: Public access – fee paid
SITE VISIT DATE: 5/31/00
BY: A. Kuhn, K. Lickliter

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Diorite

AGE(S) OF PETROGLYPHS: Mogollon

INSCRIPTION TYPE OR METHOD: Pecked

INSCRIBED SURFACE ASPECT

DIRECTIONS: East, horizontal

INCLINATIONS: 60 degrees to horizontal

ROCK SURFACE FORM: Wavy and smooth

INSCRIPTION GROOVE FORM

WIDTHS: 5-20mm

DEPTHS: <1mm

WEATHERING: Relatively uniform patination of exposed rock surfaces, exfoliation to depths of several mm.

PHOTOS:	#	Description
	Hueco1	Two x-shaped “bird tracks” pecked into patina.
	Hueco2	Images of tracks pecked into patina, with exfoliation at upper right corner.
	Hueco3	Very faint bird tracks pecked into patina, exfoliation visible at top of photo.
	Hueco4	Circle with inscribed cross, exfoliation to upper right.
	Hueco5	Daisy chain of circles and other geometrics superimposed by recent writing; images disrupted by exfoliation at lower right.

Hueco6 Same image as Hueco5.

NOTES: At this state park there are a few petroglyphs, shown above, and many pictographs not surveyed. The petroglyphs have been pecked into but not through the patina. Exfoliation is gradually removing the inscribed surfaces. Exfoliation layers are 2-5mm thick in most places, locally deeper.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: I-X Ranch
LOCATION: Lincoln Co., NM
SITE OWNED BY: State of New Mexico, Bill Stephenson
ACCESS AUTHORIZED BY: State Land Office, Bill Stephenson
SITE VISIT DATE: 6/14/00
BY: A. Kuhn, K. Lickliter, S. Casey

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Porphyritic Andesite

AGE(S) OF PETROGLYPHS: Archaic, Mogollon

INSCRIPTION TYPE OR METHOD: Pecked, Scraped

INSCRIBED SURFACE ASPECT

DIRECTIONS: Mostly south to southwest

INCLINATIONS: 80 degrees

ROCK SURFACE FORM: Planar, rough

INSCRIPTION GROOVE FORM

WIDTHS: 5-50mm

DEPTHS: 1-2mm

WEATHERING: Oldest petroglyphs are fully repatinated. Successive generations partially repatinated. Some lichen growth in inscription grooves.

PHOTOS:	#	Description
	Lincoln1	Multiple images of different ages.
	Lincoln2	Multiple images in rough, broken surface; surface spalling older than images.
	Lincoln3	Older repatinated images with superimposed unrepatinated images.
	Lincoln4	Broken concentric circle pattern, partly repatinated.
	Lincoln5	Multiple images on fractured, partially-spalled surface, older repatinated images predominate.

Lincoln6	Pencil pointing to Archaic repatinated circle; pole pointing to Archaic cone pattern; more recent spiral pattern at far right shows difference in patination.
Lincoln7	Totally repatinated concentric circles at left; more recent unrepatinated circles at right.
Lincoln8	Archaic comb pattern with some lichen growth.
Lincoln9	Wide angle of Lincoln8, including other comb patterns.
Lincoln10	Large south-facing panel with multiple images of at least two generations.

NOTES: This site is primarily the dip slope of an andesite dike, with the dip slope containing large panels of multigenerations of petroglyphs. The oldest are fully repatinated Archaic abstract geometrics. Typical Archaic images such as concentric circles, parallel lines, and connected circles are present in at least two generations and may also have been repeated by Mogollon Indians. The large panel faces are fully exposed to the sun and to wind and rain coming from the southern quadrants.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: McNaughton (formerly Simmons) Ranch

LOCATION: Luna Co., NM

SITE OWNED BY: McNaughton

ACCESS AUTHORIZED BY: Russell Baker

SITE VISIT DATE: 6/1/00

BY: A. Kuhn, K. Lickliter

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Rhyolite (welded tuff)

AGE(S) OF PETROGLYPHS: Archaic, Mogollon, Apache, recent

INSCRIPTION TYPE OR METHOD: Pecked

INSCRIBED SURFACE ASPECT

DIRECTIONS: Primarily east to southeast, some southwest and northeast

INCLINATIONS: 60 degrees to vertical

ROCK SURFACE FORM: Rough wavy-to-curving surfaces

INSCRIPTION GROOVE FORM

WIDTHS: 5-40mm

DEPTHS: Most <1mm, some up to 3mm

WEATHERING: Rock surfaces moderately patinated, some spalling.

PHOTOS:	#	Description
	Luna1-1	Horned lizard on patinated surface, fragment of rock in hand shows color of fresh unpatinated rock.
	Luna1-2	Multiple images, including concentric circles, on southwest-facing surface.
	Luna1-3	Southeast-facing weathered surface with mostly Archaic images including concentric circles, sunbursts, and fishnet patterns.
	Luna1-4	East-facing surface, partially repatinated wavy lines.
	Luna1-5	Panel of mostly Archaic images with recent spray-painted graffiti, facing northeast.

Luna1-6	Set of wavy parallel lines (Archaic) on curved rough surface, with other abstract and animal images nearby.
Luna1-7	Chain pattern of circles on patinated but partly eroded surface.
Luna1-8	Abstract image on east-facing rough surface.
Luna1-9	Panel with geometric abstractions, concentric circles at end of pointer, largely obscured by surface roughness.
Luna1-10	Archaic concentric circles and diamond patterns.
Luna1-11	Archaic wavy parallel lines on rough surface.

NOTES: This site contains both Archaic and Mogollon petroglyphs. The texture of the rhyolitic welded tuff makes some of the images difficult to see because the depth of inscription is less than the amplitude of surface roughness. Some vandalism has occurred recently. Pictures show that the rock is somewhat vuggy in places, making the rock more porous than it is in neighboring locations. The surfaces with petroglyphs are oriented in many different directions and seem to have no clear differences in degree of patination or amount of weathering; also no distinction in preservation of the petroglyphs based on aspect.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: Frying Pan Canyon
LOCATION: Luna Co., NM
SITE OWNED BY: Bureau of Land Management
ACCESS AUTHORIZED BY: Sara Schlanger
SITE VISIT DATE: 6/1/00
BY: A. Kuhn, K. Lickliter

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Sandstone

AGE(S) OF PETROGLYPHS: Archaic, Mogollon

INSCRIPTION TYPE OR METHOD: Pecked

INSCRIBED SURFACE ASPECT

DIRECTIONS: Northeast, southeast, south-to-west

INCLINATIONS: 30 degrees to vertical, horizontal, some overhangs

ROCK SURFACE FORM: Mostly planar and rough, some curved

INSCRIPTION GROOVE FORM

WIDTHS: 10-15mm

DEPTHS: 2mm

WEATHERING: Rock surfaces heavily patinated, some spalling.

PHOTOS:	#	Description
	Luna2-1	Has relief cross forms through patina, not repatinated.
	Luna2-2	Wolf tracks pecked through patina, on heavily fractured surface.
	Luna2-3	Concentric circles in pinwheel form on rough surface.
	Luna2-4	Archaic diagonal network, linked circles and comb forms overlain by Mogollon human footprints and other life forms on rough curved surface (note spall of rock left of pointer).
	Luna2-5	Starburst and other geometrics on rough fractured surface.
	Luna2-6	Concentric circles on horizontal surface, slightly repatinated.
	Luna2-7	Southeast-facing rough fractured surface with animal forms.

Luna2-8	Flat surface, rough and fractured, with Archaic and Mogollon images.
Luna2-9	Archaic cross form, Mogollon footprints and bird tracks, on rough surface.
Luna2-10	Ghost image on rough horizontal surface.
Luna2-11	Mogollon images on remnant patinated surface surrounded by spalled and scoured surfaces.

NOTES: Site is located on the west slope of Frying Pan Canyon just north of an old stock tank dam. Petroglyphs are on intact rock outcrops and boulders of a hard ferruginous sandstone. All surfaces are relatively rough and fractured. Many petroglyphs on horizontal surfaces on the tops of boulders and outcrops. A combination of Archaic abstract geometrics, with Mogollon images of footprints, animals, anthropomorphs. Very few images are completely repatinated, but many are partially repatinated, especially Archaic images.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: Mystery Stone
LOCATION: Valencia CO., NM
SITE OWNED BY: State of New Mexico
ACCESS AUTHORIZED BY: State Land Office
SITE VISIT DATE: 6/13/00
BY: A. Kuhn, K. Lickliter, S. Casey

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Andesite

AGE(S) OF PETROGLYPHS: Anasazi, recent

INSCRIPTION TYPE OR METHOD: Pecked, chiseled

INSCRIBED SURFACE ASPECT

DIRECTIONS: Northwest to northeast

INCLINATIONS: 10 degrees past vertical for Mystery Stone, 60-80 degrees elsewhere

ROCK SURFACE FORM: Wavy to planar, and smooth

INSCRIPTION GROOVE FORM

WIDTHS: Mystery Stone: V-shaped grooves 3-5mm at top
Others: 10-40mm

DEPTHS: Mystery Stone: 1-2mm
Others: <1mm

WEATHERING: Mystery Stone face slightly patinated, inscriptions unpatinated. Anasazi petroglyphs slightly repatinated.

PHOTOS:	#	Description
	Mystery1	The "Mystery Stone" inscription.
	Mystery2	Quadrapped with long tail on patinated surface with fragments of other images next to recent breaks in the rock surface.
	Mystery3	Crude face on patinated surface.

NOTES: The Mystery Stone has V-shaped grooves with sharply-defined sides and edges, and some rock dust can still be seen in the bottoms of the grooves. This inscription was obviously made with a metallic tool and, therefore, can't be older than historic age or not more than 400 years. The other petroglyphs in the vicinity are crudely done and penetrate only into the patina. These are consistent with Anasazi and older petroglyphs surveyed elsewhere.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: Petroglyph National Monument
LOCATION Albuquerque, NM
SITE OWNED BY: National Park Service
ACCESS AUTHORIZED BY: Public access
SITE VISIT DATE: 6/12/00
BY: A. Kuhn, K. Lickliter, S. Casey

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Basalt

AGE(S) OF PETROGLYPHS: Archaic, Anasazi

INSCRIPTION TYPE OR METHOD: Pecked, scraped

INSCRIBED SURFACE ASPECT

DIRECTIONS: Mostly south and southeast, some northwest
INCLINATIONS: 45 degrees to vertical

ROCK SURFACE FORM: Planar to curved, mostly rough, some smooth

INSCRIPTION GROOVE FORM

WIDTHS: Mostly 3-30mm, one image 40-110mm
DEPTHS: Most <1mm, none >2mm

WEATHERING: Natural rock surfaces extensively patinated. Petroglyphs unpatinated to partially repatinated.

PHOTOS:	#	Description
	PETRNM1	Various geometric images on a curved, rough surface.
	PETRNM2	Partially repatinated images on a rough surface.
	PETRNM3	Circles scraped partly through the patina on a curved surface.
	PETRNM4	Same as #3.
	PETRNM5	Abstract images on a rough, curved surface, partially repatinated.
	PETRNM6	Same as #5.
	PETRNM7	Large geometric pattern between walking stick and scale obscured by repatination and light reflection.

PETRNM8	Rough surface obscuring repatinated image.
PETRNM9	Surface with variable texture and random line images with wedge-shaped piece spalled from surface.
PETRNM10	Image partially broken through patina surface.
PETRNM11	Circle with tree partially obscured by reflected sunlight.
PETRNM12	Various images pecked through patina on uneven surface.
PETRNM13	Closeup of cross form in previous photo.
PETRNM14	Geometric image partially repatinated.

NOTES: Petroglyphs at this site, a side canyon of the Monument, are described by park personnel as being “a couple thousand years old.” The petroglyphs occur among scattered boulders in a narrow canyon. The level of exposure of the petroglyphs varies widely, depending on position in the canyon and orientation. Some of the photographs did not capture the image clearly, due to intense mid-day sunlight. Surfaces here are among the roughest seen at any of the surveyed sites. Several generations of petroglyphs are represented, some clearly Anasazi and others apparently older.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: Rowe Mesa Site #1
LOCATION: San Miguel Co., NM
SITE OWNED BY: U.S. Forest Service
ACCESS AUTHORIZED BY: Brent Abel, USFS
SITE VISIT DATE: 6/16/00
BY: A. Kuhn, K. Lickliter

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Sandstone

AGE(S) OF PETROGLYPHS: Archaic

INSCRIPTION TYPE OR METHOD: Pecked

INSCRIBED SURFACE ASPECT

DIRECTIONS: Horizontal

INCLINATIONS: Horizontal

ROCK SURFACE FORM: Irregular, wavy

INSCRIPTION GROOVE FORM

WIDTHS: 2-80mm

DEPTHS: 1-4mm

WEATHERING: All petroglyphs are repatinated. Iron oxide concentrated in fossil crab burrows now form resistant knobs at the surface.

PHOTOS:	#	Description
	Rowe A1	Figure that was half cover by soil (right half, below pencil) and half exposed. Except for soil in grooves of previously covered half, halves are identically preserved.
	Rowe A2	Cluster of petroglyphs previously covered with soil, prior to archeological excavation.
	Rowe A3	Cluster of petroglyphs not previously covered with soil.
	Rowe A4	Cluster of petroglyphs on surface that is part of water course.
	Rowe A5	Concentric circles, right of pencil, heavily repatinated.

NOTES: According to Brent Abel, soil over the petroglyphs is at least 3000 years old. Charcoal at the site has been dated at 5300 years, patina at 5970 years. In the area not previously covered by soil, some petroglyphs are repatinated, some not. Some repatinated petroglyphs have lichen growth. This site has a starburst pattern unlike patterns seen elsewhere. Solstice and equinox marks have been identified here. Site is in an area of P-J woodland with very little surface slope, but a shallow drainage course runs across this site. Most of the ground in the vicinity is soil-covered. Soil cover over the petroglyphs has been partially removed by archeologists to expose some of the buried petroglyphs, one of which was only half-buried by soil prior to excavation. The petroglyph shown in Photo #Rowe 1-1 was covered in the area next to the pencil in the photo, exposed in the other half. Petroglyphs are generally in fair condition.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: Rowe Mesa Site #2
LOCATION: San Miguel Co., NM
SITE OWNED BY: U.S. Forest Service
ACCESS AUTHORIZED BY: Brent Abel, USFS
SITE VISIT DATE: 6/16/00
BY: A. Kuhn, K. Lickliter

MONUMENT DESCRIPTION: Petroglyph

ROCK DESCRIPTION: Sandstone

AGE(S) OF PETROGLYPHS: Archaic

INSCRIPTION TYPE OR METHOD: Pecked

INSCRIBED SURFACE ASPECT

DIRECTIONS: Horizontal

INCLINATIONS: Horizontal

ROCK SURFACE FORM: Knobby, wavy

INSCRIPTION GROOVE FORM

WIDTHS: 10-30mm

DEPTHS: 3-5mm

WEATHERING: All petroglyphs are repatinated. Rock surface is differentially weathered, leaving iron oxide concentrations around fossil crab burrows sticking up. This weathering predates the petroglyphs, as evidenced by the petroglyphs that include the fossil burrows as part of the petroglyph image.

PHOTOS:	#	Description
	Rowe B1	Cluster with "bird tracks", sun burst, wavy lines, circle.
	Rowe B2	Cluster with spiral, orthogonal lines, dendritic patterns extending under soil cover to lower left.
	Rowe B3	Partially eroded petroglyphs with adjacent soil cover.
	Rowe B4	Petroglyph with pencil in one groove, to illustrate depth.
	Rowe B5	Petroglyph grooves across natural knob in rock.

NOTES: This site is similar in most respects to Rowe Mesa #1, except that there is no drainage course. Generally, the condition of the petroglyphs here is slightly poorer than at Rowe Mesa #1. The sandstone was identified by Brent Abel as the Santa Rosa Sandstone of Triassic age. It is well indurated and forms the cap rock of the mesa. The petroglyphs here, as at the nearby Rowe Mesa #1 site, may have been broadened and deepened by erosion or weathering, but the repatinated grooves of the inscriptions show that the weathering/erosion processes have been very slow.

SITE REPORT
WIPP PERMANENT MARKERS MONUMENT SURVEY

SITE NAME: Tonuco Mountain
LOCATION: Doña Ana Co., NM
SITE OWNED BY: Bureau of Land Management
ACCESS AUTHORIZED BY: Sara Schlanger
SITE VISIT DATE: 5/30/00
BY: A. Kuhn, K. Lickliter

MONUMENT DESCRIPTION: Petroglyph
ROCK DESCRIPTION: Sandstone
AGE(S) OF PETROGLYPHS: Archaic, Mogollon
INSCRIPTION TYPE OR METHOD: Pecked

INSCRIBED SURFACE ASPECT

DIRECTIONS: All compass points
INCLINATIONS: 20 degrees to vertical

ROCK SURFACE FORM: Flat to wavy, smooth, some fractures

INSCRIPTION GROOVE FORM

WIDTHS: 7-20mm
DEPTHS: 1-5mm

WEATHERING: Old rock surfaces patinated to reddish-brown to steel gray color, mottled together in some places. Extensive growth of chartreuse colored lichens.

PHOTOS:	#	Description
	Tonuco1	Concentric circles partly lost to spalling/erosion, repatinated.
	Tonuco2	Diamond and orthogonal line patterns, partly repatinated.
	Tonuco3	At least two generations of images, Archaic and Mogollon, latter less repatinated than former.
	Tonuco4	Archaic patterns, including one dendritic pattern with lichens.
	Tonuco5	Parallel wavy lines partly repatinated and lichens in grooves.
	Tonuco6	Sunburst and other Archaic patterns, repatinated.
	Tonuco7	Archaic geometrics, partly repatinated.

- Tonuco8 Large boulder with mottled patination, Archaic and Mogollon images.
- Tonuco9 Mogollon head with chartreuse lichens in inscription grooves.

NOTES: This site is in a steep-walled canyon that runs southeast to northwest. The sandstone cap rock has broken into boulders that line the north slope of the canyon, and the petroglyphs are concentrated on a group of these boulders. The patina varies randomly from reddish-brown to steel gray, with the latter being thicker. Petroglyphs are pecked through the patina to a depth of up to 5mm. The Archaic petroglyphs are mostly completely repatinated, and the Mogollon petroglyphs are at least partly repatinated. Chartreuse lichens are common.